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Restoration of the Delaware and Raritan Canal Outlet Locks and Towpath
Boyd Park, New Brunswick, New Jersey

By

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Abstract: The original construction of the historic Delaware and Raritan (D&R) Canal's double outlet locks in 1834 in New Brunswick, NJ included only the southern section of the outboard lock. In 1853, the northern section was added and in 1866, the inboard lock was built. Under this project, both outlet locks, which had significantly deteriorated through the years, along with the adjacent 3,000 ft. of tow path, were historically restored to as close to the condition as they existed during the peak of canal operation during the 1870's. To date this project represents the largest historical canal lock restoration in New Jersey and the nation. To the historians, the project represented the recapturing of a vital part of New Jersey history, to the non-historians it represented a direct means to getting back to the precious river front which had been abandoned for decades.

HISTORY OF THE DELAWARE AND RARITAN CANAL

The idea of creating a canal across the narrow "waist" of NJ to provide an inland waterway between Philadelphia and New York has been attributed to William Penn. The idea lay dormant until the early portion of the 19th century. The Legislature atempted on several occasions to establish a canal through the central portion of the State. However, the equally intense interest in railroad building prevented the success of either venture until 1830, when the legislature granted simultaneous charters to traverse central NJ to a canal company and a railroad company. A year later, the two companies merged forming the Delaware and Raritan Canal Company and the Camden and Amboy Railroad and Transportation Company--commonly called the "Joint Companies".

Both railroad and canal construction began in the fall of 1830. By September of 1833, the full railroad line between Bordentown and South Amboy was in operation, while only the section of the canal between Trenton and Kingston was open to vessels. A year later the entire canal was opened to through traffic, although it was not until 1838 that the canal was completed to its full design dimensions.

The route of the canal makes essentially a "y" through NJ. Water is supplied to the main canal from a 22 mile long feeder canal which diverts water from the Delaware River and empties into the main canal at Trenton (the high point of the canal). The main canal departs from the Delaware River near the head of tide just north of Bordentown. From there it runs 44 miles through central NJ before it empties into the Raritan River at New Brunswick.

As originally constructed, the main canal was 75 feet wide and 7 feet deep. It climbed through 7 locks between Bordentown and Trenton, and descended through 7 more before exiting to the Raritan River in New Brunswick. Locks were initially constructed to be 30 by 110 feet. During the course of operation a number of engineering changes were made to facilitate traffic and increase profitability -- the feeder was altered to allow for the entry of barges at Lambertville (1840); many of the upper mitre gates at locks along the main canal were replaced with drop gates to speed traffic (1849); locks were lengthened to 220 feet and the depth of the main canal was increased to eight feet (1853); a second outlet was constructed in New Brunswick (1866); and steam power was added to the locking facilities (1868).

The canal was in operation for 99 years before it was considered to be obsolete. During its active life, neighboring states were the primary benefactors because of the shipment of Pennsylvania coal to New York and the northeastern U.S. The Civil War and the industrial expansion that followed caused the 1860's and 70's to be the most prosperous years for the D & R Canal. The peak year for canal traffic is reported to have been in 1871 when 2,990,000 tons (80% of which was coal) were shipped through the Canal. 1873 was the most profitable year for the canal when earnings peaked at $1, 519,991. When the canal was opened, there was considerable optimism about the potential success of a passenger service. The trip took two days. However, the canal could not compete with the faster railroads which also operated throughout the year and passenger service was discontinued after two years.

Unfortunately, the modifications to the canal were not sufficient to maintain a prolonged competitive edge against the railroads in the freight industry. From 1871, the use of the Canal steadily declined. The completion of other railroad lines through central New Jersey aggravated a situation which was already characterized by infrequent canal repairs and increasing toll rates. After experiencing a net loss in 1893, the canal was never operated profitably again. The canal closed for the winter of 1932-33 and never reopened as a waterway. In 1937, the Pennsylvania Railroad turned the canal over to the State. It was subsequently converted to a water supply conduit for central NJ.

The Delaware and Raritan Canal is one of the most significant historic resources in New Jersey and in 1973 was listed in both the State and National Registers of Historic Places.

MEMORANDUM OF AGREEMENT (MOA)

Funding for the project was primarily as a result of the Memorandum of Agreement (MOA), between the City of New Brunswick, the NJDOT and the NJ Historic Preservation office, which detailed specific issues, including 13 terms, that were to be addressed in the restoration plans for the locks and towpath. The MOA was drafted as a mitigation measure due to the adverse effect caused by the Route 18 project which crossed directly through the D&R Canal right of way and which resulted in the demolition of the D&R canal Lock 13 (Deep Lock). The MOA was signed on January 2, 1976 and mandated that the NJDOT made funds available for the restoration of the southern most section of the canal tow path and Double Outlet Locks at Lock 14 adjacent to Boyd Park in New Brunswick, NJ.

Documentary research indicates that in order to move forward with a 100% State Funded bridge and roadway project that required a Coast Guard permit for construction (and thus Section 106 consultation), a senior NJDOT engineer signed a Memorandum of Agreement (MOA) in the mid 1970's which, among other things, committed the Department to the following to mitigate impacts to the Delaware and Raritan Canal:

1. Record the deep lock;
2. Record the lock tender's house;
3. Restore the portion of the canal and entry locks in Boyd Park, including removal of fill and restoration of channel to its original condition-- restoring walls, gates, sills and operating mechanisms using historic building materials removed from deep lock;
4. Relocate the lock tender's house to Boyd Park; and
5. Establish an interpretive center in the relocated lock tender's house

The City of New Brunswick (owner of the properties) was not a signatory to the MOA and had no obligations for compliance. $2 million was budgeted for the work based on a preliminary cost estimate.

PROJECT HISTORY

Once the roadway project was constructed, inertia set in with respect to meeting the commitments of the MOA that pertained to the canal. Oral history tells us that the negotiations held at the time the MOA was executed resulted in agreement that the definition of "restoration" as used in the MOA meant something considerably less than that defined in the *Secretary of the Interior's Standards*. The challenge became to determine exactly what should be done.

In 1980 a work plan to satisfy the stipulations of the MOA was prepared by an independent engineering firm. The estimated cost for work on the locks, canal and towpath was $5 million.

In 1983 the NJDOT dewatered the locks and a small portion of the Delaware and Raritan Canal. Detailed drawings were made according to the standards of the Historic American Engineering Record. As the result of this effort, NJDOT engineers revised the estimate for restoring the locks and towpath to $11 million. However, the Department maintained that expenditure of this amount of money to satisfy the 1976 MOA was imprudent.

Sporadic discussions between the City and the NJDOT resulted in the brief consideration of a proposal for "one wet-one dry" scheme which would be within the $2 million budget of the Department. Essentially, the proposal provided for filling one of the outlet locks completely with stone, and filling the second one to the point where the stone would be covered with approximately one foot of water for interpretive purposes. Not surprisingly, this proposal was not well received by the NJDOT's preservation specialists, the consulting parties to the MOA or the public. Frustration levels were high and the City unilaterally demolished the locktender's house.

Finally, in 1989 NJDOT agreed to hire a consultant to prepare an update of the 1980 cost estimate and, if the estimate exceeded $2 million, to develop one or more courses of action which comply to the greatest extent possible with the requirements of the 1976 MOA and the *Secretary of the Interior's Standards for Historic Preservation Projects* without exceeding the $2 million budget. Additionally, the consultant was to coordinate with the City's redevelopment plans for the area.

A. G. Lichtenstein & Associates presented the results of their study to Departmental and municipal representatives in April, 1991. At the request of the City, Lichtenstein was subsequently asked to prepare a feasibility and cost study for restoring the towpath between the Albany Street bridge and outlet locks in Boyd Park. The two studies provided the basis for consultation with the NJSHPO under both state and federal regulations.

Finally, in July, 1993 the Advisory Council concurred in a revised MOA which provided for the restoration of the double outlet locks and the rehabilitation of the adjacent towpath in accordance with the 1991 Lichtenstein study and subject to the 13 conditions required as the result of the state review process. The MOA also allowed for the execution of an agreement with the City to carry out the restoration/rehabilitation projects. NJDOT subsequently executed an agreement with the City which committed the Department to fund the work to a ceiling of $5 million. -- No additional funding had been included for design work, in-house salaries or construction oversight.

In 1995 the City of New Brunswick executed a contract with Lichtenstein for design and construction oversight services. The challenge was to

1. Satisfy the intent of the original MOA with a constrained budget;
2. Design a restoration/rehabilitation project consistent with the appropriate *Secretary of the Interior's Standards;*
3. Design a facility which invites recreational use by the public as an adjunct to the refurbishing of New Brunswick's adjacent Boyd Park (including adequate safety features);
4. Design a facility which provides increased waterfront access and complements New Brunswick's redevelopment plans for the area;
5. Satisfy applicable AASHTO and BOCA safety requirements;
6. Ensure that there is adequate water to flush/refresh the restored locks ;
7. Convey the importance of the canal and the area through appropriate interpretive displays; and
8. Provide appropriate opportunities for public input into the design process.

PROJECT SCOPE

The project was a cumulative effort amongst engineers, historians, enthusiasts, planners, politicians and researchers. Since the original plans and specifications for the D&R canal outlet locks were destroyed in a fire at the turn of the century, information used in the design were from sources which included: the archaeological investigation and cultural resource survey performed by the Rutgers Center for Public Archaeology; site investigation and field survey which included dewatering of the lock area in March 1995; evaluation of all past correspondence, comments and recommendations of the New Jersey Department of Transportation, the New Jersey Department of Environmental Protection, the City of New Brunswick, and other noted agencies/individuals; and research of all available historic data, photographs, files and plans at public libraries, institutions and agencies.

The plans, with a few exceptions, were prepared based on the conceptual restoration plans prepared by Lichtenstein under the direction of Abba Lichtenstein in 1991 - *"Delaware and Raritan Canal Outlet Locks, New Brunswick, New Jersey: Restoration Study and Cost Estimates"* and the MOA.

The project limits included the tow path immediately south of the Albany Street bridge southward to the double outlet locks and ending at the earth-filled cellular steel cofferdam at the southern end of the outlet locks and adjacent to Boyd Park. The restoration was to include the outboard and inboard locks and approximately 3,000 ft. of the adjacent tow path. Interpretive signs and features were to be added to Boyd park to give history to the setting.

The original intent of the MOA was for a complete historical restoration with a fully functional lock. However, due to the limitations on the budget ($5 Million), the project team had to redefine the scope within the guidelines of the MOA and the requirements of the city. These included:

1. Historically restoring the adjacent 500 ft of the tow path. The remaining tow path will have rip rap slopes that will essentially cover the existing timber cribwalls which could be restored at a later date should funds become available.
2. Historically restoring the outlet locks including fully operational timber mitre gates and hardware. The existing drop gate will be replicated but will not be operational. The drop gate sill and wickets will not be restored.
3. Replicating the non-existing timber swing bridge from archives records and old photos. The bridge is to be fully operational.
4. Designing for flooding conditions which included a 100-year flood elevation of approximately 6.5 feet higher than the existing tow path or outlet locks elevation.
5. Consider the exposure of the timber components to submerged and brackish conditions.
6. Providing access to the tow path from the park at various locations. This will include handicap access but will not include vehicular access except for a "golf cart" size maintenance vehicle.

Any historic artifacts found by the workers during excavations were to be put in a secure location, for future identification by the cultural resource consultant.

Site Inspection

The daunting task of dewatering the locks was bestowed on the City's maintenance crew. In March of 1995, using the timber cofferdam to the north and the cellular steel cofferdam to the south as dams, the crew managed to dewater the outlet locks with 12" pumps after two consecutive days of pumping. Approximately 2 ft. of water still remained at the bottom due to significant leaks through the timber walls on the river side and the timber cofferdam.

In general the floor of the outlet locks were uneven and had several piles of debris throughout. At the south end of the locks adjacent to the cellular steel cofferdam, the entire area was completely covered with high mounds of debris.

The only visible evidence of the swingbridge that remained at the site was a concrete pivot pad on the Boyd Park side of the island just north of the granite block wall section, which had a cast iron pivot in the center. This location was contrary to old photographs which showed the bridge on the riverside of the island. According to an unpublished NJDOT document found during our historical research, *"....at the insistence of New Brunswick's city authorities, the bridge was relocated after a flood in 1938"*. After a few exploratory digs, portions of the original concrete pivot pad were uncovered on the riverside of the island.

Outboard Lock

The southern section of the outboard lock walls constructed in 1834 were of "English Construction" and were composed of 8 rows of large granite blocks (1 ton each) laid on rubble masonry having timber sheathing on the face. The top 6 rows of the granite block walls had been displaced inward toward the lock (some areas nearly 1 foot) and a few of the blocks had been dislodged and had fallen into the lock. The timber sheathing was secured to the rubble wall, but was severely deteriorated at the top.

The northern section of the outboard lock walls constructed in 1853 to lengthen the outboard lock for longer boats were of "American Construction" and were composed of rubble masonry that was originally faced with timber sheathing. Approximately 90% of the upper half of sheathing was missing and what remained was severely deteriorated. There were also areas of missing mortar in the walls, and the top nailers for the sheathing were severely deteriorated.

On the southern tip of the island separating the two locks, there were several missing stones. The northern end of the island consisted of a timber cribwall of horizontal logs which formed a nose. The top 3 to 4 rows were missing and the remaining timber was severely deteriorated above the mudline.

The massive timber mitre gates, which originally existed at the downstream end of the outboard lock, were not in place. The mitre gates at the upstream end were in place, but severely deteriorated and separated from its support. One gate (believed to be the downstream gate) was found leaning against the granite walls at the south end and another was lying on the floor of the lock. The gates were severely deteriorated with open mortise and tenon joints, rusted support straps and anchors, bent wicket rods, rusted wickets and the upper sections of the gate above the tidal zone, which included missing balance beam and pivot connections. The gates consisted of 2 pairs of mitre gates having 1 row of 6 wickets.

Inboard Lock

The inboard lock walls constructed in 1866 were also of "American Construction" composed of rubble masonry that was originally faced with timber sheathing. Approximately 90% of the upper and 70% of the lower halves of sheathing were missing and what remained was severely deteriorated. There were also areas of missing mortar in the walls, and the top nailers for the sheathing were severely deteriorated.

Only one mitre gate at the downstream end was in place, the other was leaning against the lock wall. The drop gate at the upstream end of the inboard lock was in the "open" or horizontal position atop the timber sill. The mitre gates were severely deteriorated with open mortise and tenon joints, rusted support straps and anchors, bent wicket rods, rusted wickets and the upper sections of the mitre gate above the tidal zone, which included missing balance beam and pivot connections. The downstream mitre gates consisted of 2 pairs of mitre gates having 2 rows of 4 wickets each. The drop gate had a missing timber sheathing and could only be inspected on the downstream side for fear of damaging the gate to lift it. The drop gate had 5 sill openings which were clogged with debris.

Tow Path

The timing of the inspection at the end of the winter months was critical to the inspection of the tow path so that the inspection could be conducted in the absence of the heavy growth which normally existed on the tow path. The towpath consisted of a timber cribwall with 12"x12" horizontal timber logs and 8"x8" timber deadmen. The face of the cribwall was plumb on the riverside and sloped on the park side. In general, the top few timbers were missing and the remaining timbers above the mudline were severely deteriorated. In addition, there were several breaches and areas of severe undermining that were typically being held together by the root system of the existing trees.

RESTORATION OF THE DOUBLE OUTLET LOCKS

The proposed plans included contingencies which allowed for a final determination as to the extent of the repair and rehabilitation works to be made when specific work items were uncovered and exposed by the contractor. It was noted to all bidders prior to bidding and included in all contract documents that the plans were for bidding purposes and that the exact limits, dimensions, details and configurations were to be determined in the field as the construction progressed.

Timber flooring existed only in the outboard lock within the limits of the granite block wall section. The existing timber flooring had minor deterioration at the southern end of the outboard lock and was repaired in-kind with new timber. The remaining timber flooring in the outboard lock was in fair condition. No repairs were recommended for this section. The northern section of the outboard lock and the inboard lock had an uneven stone flooring. All silt and debris was removed from the outlet locks.

The existing historic concrete and timber snubbing posts that existed on the island and park were in good condition and were designated to remain.

Outboard Lock Walls (Granite Block Section)

The proposed repair of the outlet lock granite block walls were to be executed with minimal disturbance to the original historic fabric still existing at the outlet locks. The plans proposed to reset the dislodged granite blocks (top 6 rows). Since the timber sheathing at this section was below water and out of view, a nailer was installed to the outside face of the existing sheathing below the granite blocks to secure the original deteriorated timber sheathing in place. The granite blocks and rubble stones which may have been part of the original outlet lock walls and which had fallen into the canal were to be retrieved from the locks and reused in the resetting and repair of the walls.

The Contractor was required to retain the services of a professional photographer to photograph elevation views of the granite block walls prior to resetting. Each granite block along a visible face was numbered prior to photographing, thereby documenting the stones exact location in the wall. The walls were then dismantled in sections and then reset true to line, grade and position as shown in the photographs. To facilitate the handling of the blocks, the contractor drilled holes in the top of block and installed a lifting insert to lift and move the blocks.

Outboard Lock Walls and Inboard Lock Walls (Rubble Masonry Section)

The plans proposed to replace all missing and loose stones. The stones were reset using the existing stones that were retrieved from the locks. A mortar mix consisting of 3 parts lime to 6 parts sand and 2 parts cement by volume was specified. This mix had been approved by the HPO for use on other historic restoration projects. Water was added to form the proper consistency but was not to exceed 5½ gallons per bag of cement.

Timber

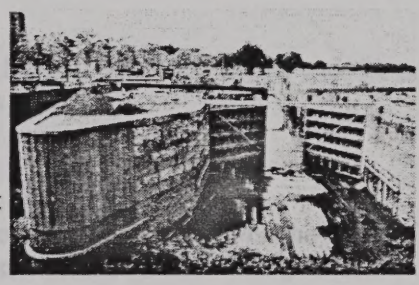
Southern yellow pine lumber (Pinus Taeda) was the preferred timber on this project instead of oak due to the "poor" performance of the oak wood on previous canal restoration projects (Hugh Moore Park and Canal Museum). To improve the longevity of the timber, all timbers were treated with chromated copper arsenate (CCA) with the following minimum retention properties:

Timber Items	Minimum Retention Lbs/Cu. Ft. of Timber
Mitre gates, drop gate, cribwall (towpath) and timber fender	1.5
Sheathing, nailers and caps	1.5
Swingbridge, and treadways & planking (at Mitre Gates)	1.0
Pedestrian railing and railing gates	0.4

The timber was supplied by Paul M. Jones Lumber Company, Inc. of Snow Hill, Maryland and pressure treated by Wood Preservers, Inc. of Warsaw, Virginia. The timber mitre gates, drop gate and swingbridge were fabricated by Vermont Timber Works of South Londonderry, Vermont.

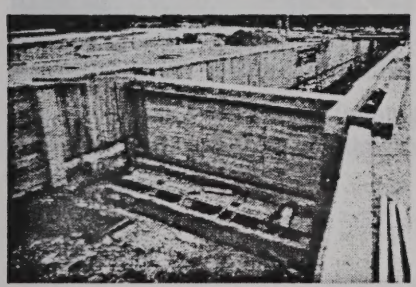
Timber Gates

The plans proposed that the remains of the existing 3 pairs of mitre gates and the drop gate were to be removed from their existing location, field measured and documented with sketches and photographs, stored and submerged during construction and then placed on the floor of the inboard lock floor for preservation after completion of the works.



The original mitre gates were made from heavy oak timber members that were assembled with double mortise and tenon joints. When closed, the gates abutted an oak mitre sill, which was still in good condition. All gates were historically replicated and replaced. The sills which had been in great shape were reused.

The drop gate consisted of heavy timber framing with timber sheathing on both faces. The area between the timber sheathing was filled with gravel to act as counter weights to counter natural buoyancy. In its closed position, the gate was angled to the vertical to allow it to fall under its own weight when opening.



The operating mechanism of the drop gate consisted of 2 rows of 5 paddle gates. After further investigation during construction, the paddles were found to be "frozen" in the closed position. Since it was proposed to lock the drop gate in the "closed" position, it was imperative that the inboard lock had sufficient water flow. One row of paddles were removed and placed on the inboard lock floor for future investigation. The new drop gate was secured in the closed position and all debris within the existing timber sill was removed.

All dimensions and configurations for the new gates were taken from accurate field measurements of the existing deteriorated mitre gates and drop gate. Missing portions of the existing gates were determined from old photographs, historical documentation, and old specifications from the Bald Eagle and Spring Creek Lock . Additional details of the iron pivot bottom, collar, wickets, wicket rods and bumpers were adapted from plans of the Kingston Lock on the D & R Canal. The details were judged by both historians and engineers to be a close replica of the historic details as evidenced by old photographs.

Hardware

The hardware for the mitre gates, drop gate and swingbridge were replicated following the contractor's field verification of dimensions and details of the respective items. Items that could not be field verified were replicated from the plans based on details from the Kingston Lock plans and historical records and specifications.

Cast iron (Gray Iron castings conforming to AASHTO M105, Class 30B) hardware was used for the following:

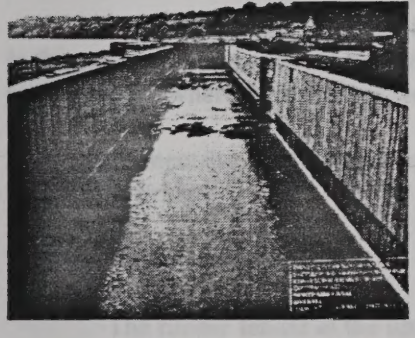
Mitre Gates	Bumpers, Wicket Frames, Wickets, Stop Plates, Wicket Collars, Pivot Sockets, Seat and U-spike
Drop Gate	Pivot Assembly
Swingbridge	Pivot, Pivot socket and Wheels
Granite block walls	Spikes (1½" square) and Ties

Hot-dipped galvanized grade 50 steel (painted brown) in accordance with the Inorganic Zinc Coating System was used for the following since these items experience tension while in use:

Mitre Gates	Wicket Rods, Collars, Coupling, Heel Band, plates, Rods w/upset ends, Turnbuckles, Hangers, Straps, Clevises, Wicket Rod Handles
Swingbridge	1" Dia. Rods with threaded ends, Turnbuckles, hanger plates, Steel Regulator, Clevises, Hanger Pins, and nuts.

Galvanized steel threaded bolts were used for the nailers as they are hidden from view by the sheathing. Galvanized steel nails were specified for the sheathing as only the nail head was visible.

Timber Sheathing

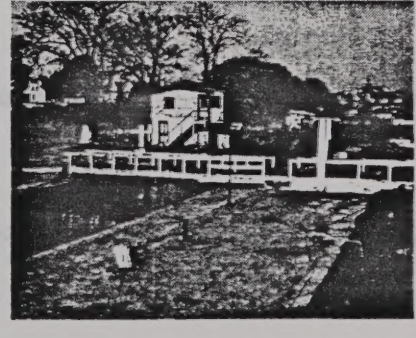


For the lengthened section of the outboard lock and within the limits of the inboard lock it was proposed to leave the lower half of the existing historic 2" thick timber sheathing in place (for economy) and replace the upper half of the timber sheathing with new timber sheathing. The existing lower timber sheathing was held in place by a new timber nailer secured to the wall.

The deteriorated and missing sheathing for the upper half was replaced throughout with new 2" x 10" treated timber sheathing. A viewing window was installed in the sheathing on the inboard lock to show the original rubble masonry with the original timber remains.

Additional research (photographic and field reconnaissance) confirmed that a timber capping once existed on top of the timber sheathing within the limits of the rubble masonry walls. Therefore, timber capping was constructed at top of sheathing.

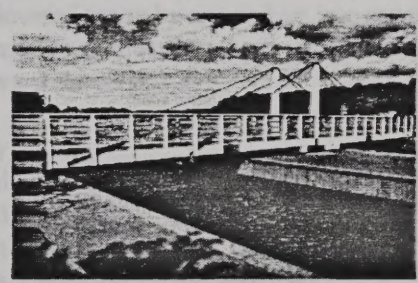
Swingbridge



Based on the old photographs, the original swing bridge was thought to be a wooden king post structure with wooden pedestrian bridge rail, wooden ramps on either ends leading off the bridge and steel cables suspended from the king post. The pedestrian bridge rail had openings on both sides for access to the island.

The historic geometry and details of the proposed pedestrian swing bridge were based primarily on the old photographs of the outlet locks and supplemented with details taken from plans of the vehicular swing bridge at the D&R Canal Kingston Locks. Details from the as-built plans of the Rideau Canal that was built in 1866 (the same year that the inboard lock of the D&R canal outlet locks was added), were used to replicate the details for the pivot and wheel system that the bridge turned about. Because the wheels were hidden from view, the contractor proposed using galvanized cast high tensile ductile iron rigid wheels with Timken bearings.

The biggest issue during the design phase, was the proposed width of the bridge. A width of 10 feet out-to-out was chosen based on field investigations and survey plans done by Lichtenstein, which showed a discontinuous area in the concrete walkway (approximately 10 feet in length) on the Raritan River side of the lock in the extant location of the original swing bridge. The thought was that, the discontinuity in the walkway represented the approximate outer limits of the swing bridge, since the concrete walk was probably poured while the existing bridge was in place to the fascia of the bridge. However, the feeling amongst the historic community was for an 8 foot wide walkway. With the 10 feet out-to-out dimension, the minimum clear width is 8'-2" between the tapered king posts. The bridge was designed in accordance with the latest AASHTO Standard Specifications for Highway Bridges.



Another issue that had to be addressed during the design phase was the height of the pedestrian bridge railing. The original pedestrian bridge rails appeared to be wooden posts with a wooden top rail and cap. The current AASHTO Code required that the pedestrian bridge rail be 3'-6" minimum in height and openings between the rails should be such that a 6" sphere cannot pass through. By the present code standards, the "historic" rail from the old photographs would not meet code specifications for use on a public facility. The proposed pedestrian bridge rail was designed to have the same features as its historic counterpart but was supplemented with wooden intermediate rail elements in order to meet code requirements. In addition , the king post, fascia side of beams, railing posts and top rails were painted white to illustrate what existed historically. As previously stated, the steel hardware was painted brown.

For safety reasons, two maintenance access gates to the island were installed, instead of the original openings in the pedestrian bridge rail to prevent public access to the island. They were located on either side of the bridge at the same location where the openings were from the photos.

To meet the ADA Code, longer handicap access ramps to the swing bridge were proposed and installed at both ends of the bridge.

Timber Fender

The timber fender at the upstream end of the island at the locks was reconstructed with new treated timber. The bottom timbers below the mudline of the timber fender were deemed reusable and were reused in construction. The construction was similar to the cribwall which will be described later.

RESTORATION OF THE TOWPATH

The original MOA mandated that the entire 3,000'± of towpath be historically restored. However, due to the limited budget, different sections were proposed:

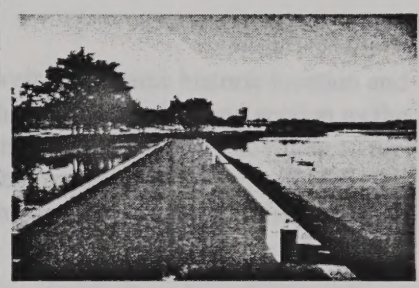
1. The historic restoration of 225 ft of tow path using timber members
2. A non-historic restoration which would use rip rap stone slope protection that would entomb the existing timber cribwall until funds are available for their historic restoration.

The preliminary plans proposed to limit the historic reconstruction to 425 ft. beyond the lock chambers or up to Station 17+00. However, based on the construction cost the length of historic towpath cribwall construction was decreased to stay within the project budget. The proposed 225' limit of the historic reconstruction encompassed the field of view for a person standing at the focal or main attraction point, that being the lock chamber area. It was far enough around the "bend" of the towpath to create the illusion that the timber cribbed towpath extended indefinitely.

The following describes each towpath section developed:

Cribwall (Historic section)

The design of the historic cross section of the towpath was developed based on historical documentation, historic maps, archeological reports, historical photographs and field measurements taken during the field investigation. The most thorough description came from the Bianchi and Rutsch report for the 1979 Archeological Monitoring of a pipe crossing of the D & R Canal within the project site. Their report indicated that the towpath was composed of heavy timber cribbing filled with a red clayey loam and crushed red shale rock. A frame of two parallel sets of heavy white pine timbers, measuring from 11 inches to 1 foot square, were connected by unshaped logs (deadman) placed perpendicular to the frame. The ends of the deadmen were shaped into a flared dovetail tenon by axe and set into sawn mortises 4 to 5 feet apart in each course of framing, except for the top frame beam. The timbers on the river side were stacked vertically, while the timbers on the canal side were stepped 3" to 4" toward the river.

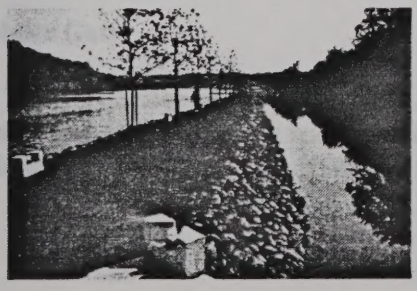


The existing timber cribwall was in a badly deteriorated state with many sections completely decayed and others only partially standing within the tidal zone. The deadmen ends were generally deteriorated providing little or no lateral support to the parallel timbers. Piece meal reconstruction would have been unattractive and questionable as to how long it would last before future repairs would become necessary. It was therefore proposed to entirely remove the rotting cribwall and reconstruct it with the historically correct dimensions and materials. The top width between top timbers was set at 14 ft. as per the existing and the timbers on the canal side stepped 3" between rows. All trees were removed within the historic section limits and no trees were planted within these limits since historically none had existed.

For economic reasons, it was proposed to use 1" steel tie-rods which were galvanized and coated with coal tar coating, instead of the "historic" unshaped logs for the deadmen since the deadmen would be backfilled and thus hidden from public view. A timber plug was used at the ends of the tie rods to give the illusion that they were the timber deadmen ends and thus the same view as existing.

Riprap slopes (Non-historic section)

A non-historic towpath section for the remainder of the towpath was developed entirely out of economic necessity. The vast quantity of sawn, treated and placed timber required made it cost prohibitive to reconstruct the entire towpath to its historical beginning given the available project budget.



The non-historic section used maintains the historic 14 ft. towpath width but utilizes riprap slopes. Although it is unlikely that the existing crib wall can be salvaged as part of a future rehabilitation project, it was left in place as requested by the State Historic Preservation Office and simply covered by the riprap stone, although localized conflicts with riprap layer were removed. In this manner the timber was preserved to the best reasonable means for future archaeological investigations or considerations. An Impervious liner (Claymax

600SP Geosynthetic Clay liner) was used below 12" thick riprap on the canal side. An 18" thick layer of riprap was used on the river side (designed for the flow of the Raritan River). A 3" thick layer of crushed red shale (prevalent in the New Brunswick area) mixed with stabilizer (a patented non-toxic organic binder) was used for the top surface of the towpath section.

Water Flow

The outlet locks, canal and towpath up to near Albany Street Bridge were restored under this same construction contract. Clean water is supplied to this portion of the canal through the Albany Street valve.

Lichtenstein performed a hydrologic and hydraulic study for the City which proposed to cut the existing steel cofferdam, downstream of the locks, down to elevation 4.0 to coincide with the design water elevation of the previous Boyd Park design and the installation of the riprap slope towpath section at the location of the historic overflow (waste weir). The top of the proposed waste weir was also set at elevation 4.0.

Waste weir

The cultural resource survey performed by Rutgers Center for Public Archeology indicated that a timber bridge originally existed at the 212 ft. long tow path overflow weir. Due to the estimated cost of a new timber bridge, it was decided that it could not be reconstructed within the budget allocated for the project, and therefore was excluded from this contract.

Due to economic reasons, we proposed the construction of an overflow weir at the same historic location and the same historic length of 212 feet. The reconstructed weir was composed of the same materials and section as the riprap slope towpath section, except that 18" thick riprap was used for the slopes and the top of weir. The riprap on top of the weir was constructed at elevation 4.0 and grouted. The existing timber boxes, sheeting, floor, cribbing and hardware for the original historic canal overflow weir remained undisturbed. The impervious liner, geotextile and riprap were placed within the limits of the weir leaving historic timbers in place.

The reconstruction of the weir does not preclude the reconstruction of the historic timber bridge over the weir or reconstruction of the historic weir should funds become available for it at a future date.

Pedestrians Footbridges

Three (3) new modern 120' span, painted prefabricated truss bridges were provided along the proposed towpath restoration. Two (2) of the bridges were placed near the ends of the overflow weir section since the weir would be non-traversable to pedestrians due to its slippery nature (wet riprap). The bridges were designed to meet AASHTO and ADA requirements (handicap accessible) with a 6 foot walkway. The bridges would be used by pedestrians to walk from the Park to the towpath and visa versa. The bridges were prefabricated steel tubular thru-truss bridges manufactured by Steadfast Bridge Company in Fort Payne, Alabama, with a timber plank deck. The abutments were cast-in-place concrete. The bottom of the bridge superstructures was set to have a 4'-0" minimum clearance to the normal canal water elevation of 4.0 at the centerline of bridge so that a canoeist can traverse the canal below each of the bridges.

Sluice Gate

A Sluice gate was proposed and installed at the downstream end of the outlet locks adjacent to the steel cofferdam to flush the lock water and for presentations of lock operation. The proposed gate was an aluminum framed sluice gate that was faced with timber to be in keeping with the historic context of the locks.

Interpretive Features

A Powerhouse originally existed near the drop gate on the Boyd Park side of the locks. During Rutger's Center for Public Archaeological investigation of the site the original foundation for the building was discovered, unearthed and documented with photos and sketches. The contract documents required the contractor to locate the foundation and set stones in sand above the walls to interpret the building foundation. In addition, at four (4) locations throughout the project limits, interpretive signage was designed and constructed to illustate the history of the D & R Canal and it's significance to the City of New Brunswick.

Safety Measures for Park Patrons

Lighting - Modern low level lighting was installed on entire towpath, landings at footbridges and sides of swingbridge, and pole lights were installed within the park for security and night use. The electrical system was required to be waterproof and capable of submersion due to past flooding problems.

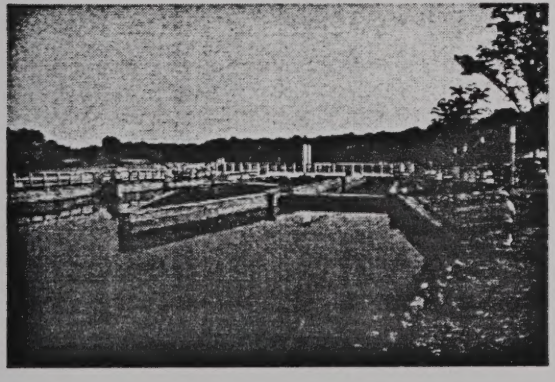
Railings - The original locks did not have railings at the locks. At the City's request, railings were included surrounding the outlet locks for safety purposes. The railings were not provided in the island area as access to the island from the swingbridge will not be permitted to the public. The City was concerned with potential liability for public safety as the Boyd Park and lock restoration will attract many people. The City had already had a history of drowning in the locks. The City submitted further justification for the need for railings to the Historic Sites Council for review and received their ultimate approval.

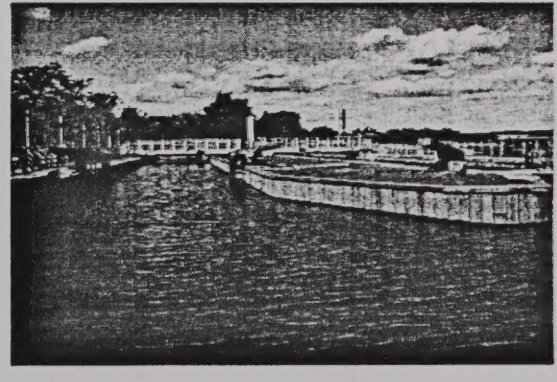
Ladder Rungs- Although not a part of the historic fabric, ladder rungs were installed in the lock walls (3 sets per lock) so as to provide a means for a person who may have fallen in the lock to climb out of the lock chamber.

The **Landscaping** included installing Platanus Acerfolia (London Plane) trees on the north end of towpath only to provide shade during hot summer months for the public wishing to picnic or walk the length of the towpath from the locks. Groundcover plants (Parthenocissus Quinquefolia, otherwise known as Virginia Creepers) were planted at the top of canal side riprap, crushed red shale stabilized with an organic soil additive (Stabilizer produced by Stabilizer, Inc., Phoenix, Ariz.) to produce a firm, stable towpath & island surface, and stabilized crushed stone surface (grey stone) was used on park side of lock to match park paths.

Summary

The construction of the project was substantially completed in time for the City of New Brunswick's Raritan River Fest on September 26, 1998. At the opening ceremony the Mayor James Cahill of the City of New Brunswick dedicated the project. The final construction cost was $5,250,000.





The project benefitted from the experience of the Delaware and Raritan Canal Commission (which maintains the rest of the canal as a recreational facility) and the collective knowledge of the Canal Society of New Jersey--a group of knowledgeable and dedicated canal enthusiasts who continually urged us to expand our vision in the direction of a full, working restoration.

The final product was a twofold success - it gave the public access to the precious waterfront along the Raritan River from Boyd Park and gave a historic representation of the locks as they operated during the late 1800's. The project was realized due to the coordinated efforts of the New Jersey Department of Transportation, the City of New Brunswick, archaeologists, historians, contractors and engineers working together for a common goal.

Acknowledgments

The resulting restoration is very much the result of a cooperative effort, and the dedication of all of those who have been involved is apparent in the outcome.

Design Team

A.G. Lichtenstein & Assoc., Inc., was the lead engineering consultant on the project, and was responsible for the design team coordination, site inspection, historic research, canal lock and tow path designs, and resident engineering.

Parsons + Fernandez - Casteleiro was the project architect responsible for the architectural elements including the modern pedestrian bridges and the interpretive features.

Arnold Associates was responsible for the landscaping design.

H. M. Brandston and Partners, Inc. was responsible for the path lighting.

Alan Volle & Associates was responsible for the construction cost estimating of the project prior to bidding.

Construction Team

Robert Charles Enterprises - General Contractor

Cultural Resource Assessment (CRA) - Archaeological inspection and documentation of cultural resources

The project was coordinated with:

City of New Brunswick.

New Jersey Department of Transportation - Bureau of Environmental Services, Structures; and Construction.

New Jersey Department of Environmental Protection - Historical Preservation Office

Canal Society of New Jersey

D&R Canal Commission